

**Test Report:  
Total Ionizing Dose Testing of  
JANS2N2222 Silicon NPN Switching Transistor**

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## 1. Introduction

The 2N2222 NPN silicon bipolar switching transistor manufactured by Microsemi Corp was tested for its response to ionizing radiation at various dose levels, up to a dose of 40 krad(Si).

## 2. Procedure

Four parts were tested. There was no control device. The parts were exposed to gamma rays emanating from a Co60 cell at a dose rate of 20 mrad(Si)/s without any applied electrical bias. Parametric values were measured prior to the first exposure and then immediately following each incremental dose.

## 3. Part Information

**Table I.**  
2N2222 Device and Test Information

<b>Part Number:</b>	JANS2N2222
<b>Manufacturer:</b>	Microsemi
<b>Lot Date Code (LDC):</b>	0315
<b>Quantity to be Tested:</b>	4
<b>Serial Numbers of Control Sample:</b>	NA
<b>Serial Numbers of Radiation Samples:</b>	1, 2, 3, 4
<b>Part Function:</b>	Transistor
<b>Part Technology:</b>	Bipolar
<b>Package Style:</b>	TO-18 (3-Pin)
<b>Test Equipment:</b>	Parametric Analyzer, dual power supply
<b>Test Engineer:</b>	J. Forney
<b>Dose Levels (krad (Si))</b>	0, 5, 10, 15, 20, 30 and 40
<b>Target dose rate (rad (Si)/sec)</b>	0.02

#### 4. Test Setup for Measuring Parametric Values

The collector of the transistor was biased at 10 V and the emitter was grounded. Voltage ( $V_A$ ) was applied to the transistor's base connection through a  $1\text{ k}\Omega$  resistor.  $V_A$  was scanned from 0 V to 11.1 V in steps of 0.1 V. Base current ( $I_b$ ) and collector current ( $I_c$ ) were measured at each step.  $V_{eb}$  was calculated from  $V_B - 1000 \cdot I_b$ .

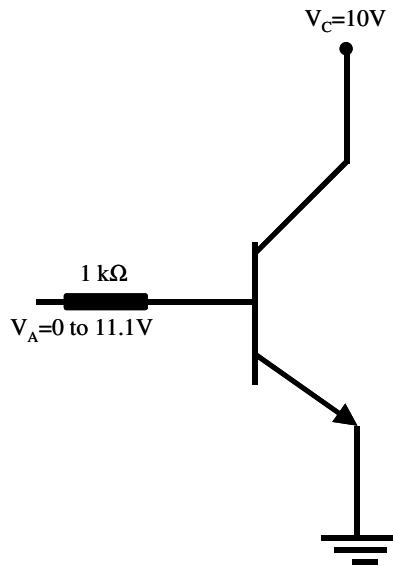


Fig. 1. Bias conditions for testing the 2N2222 transistor.

#### 5. Results

The following parametric values were monitored as a function of ionizing dose:

- Forward-Current Transfer Ratio
- Collector-Emitter Saturation Voltage
- Base-Emitter Voltage

##### a) Forward-Current Transfer Ratio

CTR was measured for the following four conditions:

- $I_c=0.1\text{ mA}, V_{cd}=10\text{V}$
- $I_c=1.0\text{ mA}, V_{ce}=10\text{V}$
- $I_c=10.0\text{ mA}, V_{ce}=10\text{V}$
- $I_c=40.0\text{ mA}, V_{ce}=10\text{V}$

(The data sheet specifies a measurement at  $I_c=150\text{ mA}$ . This could not be done because the power dissipated would be too large. Therefore, we opted to do the measurement at 40 mA.)

Table II  
CTR at 0 krad(Si).

0 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	101	121	115	102	109.75	9.84	50.00
CTR @ 1.0 mA	124	143	136	122	131.25	9.98	75.00
CTR @ 10 mA	146	161	156	141	151.00	9.13	100.00
CTR @ 40 mA	179	193	188	171	182.75	9.74	NA

Table III  
CTR at 5 krad(Si).

5 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	96	98	88	89	92.75	4.99	50.00
CTR @ 1.0 mA	118	121	125	109	118.25	6.80	75.00
CTR @ 10 mA	142	146	152	133	143.25	7.97	100.00
CTR @ 40 mA	176	179	186	164	176.25	9.18	NA

Table IV  
CTR at 10 krad(Si).

10 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	86	83	81	74	81.00	5.10	50.00
CTR @ 1.0 mA	108	104	101	99	103.00	3.92	75.00
CTR @ 10 mA	137	138	137	125	134.25	6.18	100.00
CTR @ 40 mA	167	173	168	155	165.75	7.63	NA

Table V  
CTR at 15 krad(Si).

15 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	81	68	67	61	69.25	8.42	50.00
CTR @ 1.0 mA	99	84	101	91	93.75	7.80	75.00
CTR @ 10 mA	134	133	129	118	128.50	7.33	100.00
CTR @ 40 mA	165	166	162	149	160.50	7.85	NA

Table VI  
CTR at 20 krad(Si).

20 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	70	70	56	54	62.50	8.70	50.00
CTR @ 1.0 mA	94	83	88	75	85.00	8.04	75.00
CTR @ 10 mA	136	128	128	115	126.75	8.69	100.00
CTR @ 40 mA	163	163	161	144	157.75	9.22	NA

Table VII  
CTR at 30 krad(Si).

30 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	61	47	47	45	50.00	7.39	50.00
CTR @ 1.0 mA	93	76	76	70	78.75	9.91	75.00
CTR @ 10 mA	141	112	112	110	118.75	14.86	100.00
CTR @ 40 mA	200	200	180	160	185.00	19.15	NA

Table VIII  
CTR at 40 krad(Si).

40 krad	DUT#1	DUT#2	DUT#3	DUT#4	Average	St. Dev.	Spec
CTR @ 0.1 mA	60	38	40	39	44.25	10.53	50.00
CTR @ 1.0 mA	88	72	72	66	74.50	9.43	75.00
CTR @ 10 mA	129	110	107	100	111.50	12.40	100.00
CTR @ 40 mA	195	185	179	157	179.00	16.08	NA

The results above show that the part starts to go out of specification between 30 krad(Si) and 40 krad(Si).

b) Base-Emitter Saturation Voltage

Table IX  
Vbe (measured with Ic=150 mA and Ib=5 mA.)

Dose	Dut#1	DUT#2	DUT#3	DUT#4	Average	St. Dev	Spec.
0	0.8	0.8	0.8	0.8	0.80	0.00	>0.6
5	0.8	0.8	0.8	0.8	0.80	0.00	>0.6
10	0.8	0.8	0.8	0.8	0.80	0.00	>0.6
15	0.8	0.8	0.8	0.8	0.80	0.00	>0.6
20	0.8	0.7	0.7	0.7	0.73	0.05	>0.6
30	0.8	0.7	0.7	0.7	0.73	0.05	>0.6
40	0.7	0.7	0.7	0.7	0.70	0.00	>0.6

The data shows that Vbe meets specifications up to the maximum total dose of 40 krad(Si).

c) Collector-Emitter Voltage

Table X  
Vce (Measured with Ic=150 mA and Ib=10 mA)

Dose	Dut#1	DUT#2	DUT#3	DUT#4	Average	St. Dev	Spec.
0	0.104	0.103	0.102	0.104	0.10	0.00	<0.3
5	0.104	0.11	0.107	0.113	0.11	0.00	<0.3
10	0.113	0.109	0.112	0.118	0.11	0.00	<0.3
15	0.114	0.115	0.115	0.115	0.11	0.00	<0.3
20	0.115	0.115	0.115	0.116	0.12	0.00	<0.3
30	0.115	0.114	0.115	0.116	0.12	0.00	<0.3
40	0.112	0.113	0.114	0.113	0.11	0.00	<0.3

## 6. Conclusions

The four parts tested passed Vce (saturation voltage) and Vbe up to a total dose of 40 krad(Si). The forward current transfer ration went out of specification for two devices between 30 and 40 krad(Si).